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NATIONAL DAM SAFETY PROGRAM. KLONDIKE LAKE DAM (MO 30019), MISS--ETC(U)
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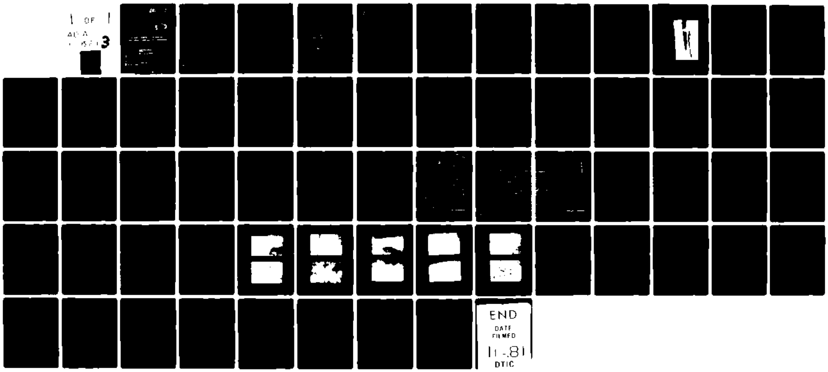

LEVEL II

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MISSOURI - KANSAS CITY BASIN

KLONDIKE LAKE DAM

ST. CHARLES COUNTY, MISSOURI

MO 30019

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1980

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

MISSOURI - KANSAS CITY BASIN

KLONDIKE LAKE DAM

ST. CHARLES COUNTY, MISSOURI

MO 30019

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Klondike Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Klondike Lake Dam (Mo 30019):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classifed as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

2) Overtopping of the dam could result in failure of the dam.

3) Dam failure significantly increases the hazared to loss of life downstream.

SUBMITTED BY: ______________________________ ____________________
Chief, Engineering Division Date

APPROVED BY: ______________________________ ____________________
Colonel, CE, District Engineer Date

KLONDIKE LAKE DAM - MISSOURI INVENTORY NO. 30019

ST. CHARLES COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

AUGUST 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Klondike Lake Dam
State Located:	Missouri
County Located:	St. Charles
Stream:	Tributary of Missouri River
Date of Inspection	24 April 1980

The Klondike Lake Dam was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of the hydrologic/hydraulic investigations, the present general condition of the dam is considered to be somewhat less than satisfactory. ~~The following~~ deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam.

1. Evidence of seepage, soft and wet ground near the toe of the center of the dam; soft ground and flowing water at the intersection of the toe of the dam and the right abutment; and running and standing water and cattails downstream of the toe of the dam was observed. Uncontrolled seepage could develop into a piping condition that can lead to failure of the dam. Saturation of the soil adjacent to the dam can weaken the foundation and impair the stability of the dam.

2. The right bank of the outlet channel for the emergency spillway at a point adjacent to the dam was eroded to an extent that spillway releases within the capacity of the outlet would not be confined to the channel. Damage by unconfined spillway releases to the dam and to other areas downstream of the dam can occur during periods when lake outflow passes the emergency spillway.

3. Erosion of the grass covered upstream face of the dam apparently by wave action and/or by fluctuations of the lake surface level has created a near vertical bank approximately 6-to-12 inches high at the normal waterline. A grass covered slope is not considered adequate protection to prevent erosion by wave action or fluctuations of the lake level.

4. Erosion that appears to be due to overland drainage has created a small gully about 18 inches deep in the downstream face of the embankment at the right abutment. Loss of embankment material can impair the structural stability of the dam.

5. A significant growth of brush and small trees were present on the upstream slope of the dam. There were also numerous small trees on the downstream face of the dam. Tree roots can provide passageways for lake seepage which could lead to a piping condition (progressive internal erosion) resulting in failure of the dam. Brush may conceal animal burrows which could also provide passageways for lake seepage.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Klondike Lake Dam, which is classified as intermediate in size and of high hazard potential, is specified to be the Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that both spillways, principal plus emergency, are inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillways are capable of passing lake outflow corresponding to about 20 percent of the PMF lake inflow and the lake outflow resulting from the 1 percent chance (100-year frequency) flood. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be two miles. Accordingly, within the possible damage zone are two dwellings, several farm buildings, a railroad track, and a marina.

A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.

Ralph E. Sauthoff

Ralph E. Sauthoff
P. E. Missouri E-19090

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P.E. Missouri E-9168

OVERVIEW OF KLONDIKE LAKE DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

KLONDIKE LAKE DAM - ID. NO. 30019

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

KLONDIKE LAKE DAM - I.D. NO. 30019

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Klondike Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the above dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams", dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Klondike Lake Dam is an earthfill type embankment rising approximately 40 feet above the natural streambed at the downstream toe of the barrier. The embankment has an upstream slope of 1v on 2.8h which breaks at a point about 5 feet below the dam crest to approximately 1v on 10h to form a berm approximately 10 feet wide

that serves to protect the upstream face from erosion by wave action. The berm elevation varies and it could not be determined if it extended across the entire length of the dam. The crest of the embankment is about 12 feet wide, and the downstream slope is 1v on 2.2h. The length of the dam is approximately 710 feet. A plan and profile of the dam are shown on Plate 3 and a cross section of the dam is shown on Plate 4. At normal pool elevation the reservoir impounded by the dam occupies approximately 21 acres.

The dam has both a principal and emergency spillway. The principal spillway, which is located to the right of the center of the dam, consists of an 18-inch diameter steel drop inlet pipe with an antivortex plate (see Photo 3) and a 12-inch diameter steel outlet pipe. A woven wire fence that acts as a trash rack surrounds the inlet to the riser pipe to protect the spillway from clogging. The spillway outlet pipe (see Photo 4) discharges to the original stream channel at the toe of the dam.

The emergency spillway is located at the left or north abutment (see Photo 5). The spillway outlet channel, an excavated earthen trapezoidal section, is cut into the hillside with an earth bank constructed on the downhill or right side to confine flow to the channel. The channel, which extends approximately 280 feet from the centerline of the dam, is constructed to conduct flow towards the adjacent valley and away from the dam. However, due to erosion of the bank near the dam (see Photos 7 and 8), flow passing the emergency spillway discharges near the downstream face of the dam and across the relatively flat area downstream of the dam. A profile of the emergency spillway showing both channels, i.e., the intended outlet and the eroded outlet, is shown on Plate 5. A cross-section of the spillway channel at the crest location is also shown on Plate 5.

b. Location. The dam is located on an unnamed tributary to the Missouri River, about one-tenth mile north of State Highway 94 and approximately 2 miles east of the Town of Augusta, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 7, Township 44 North, Range 2 East, within St. Charles County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as intermediate (per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. Hazard Classification. The Klondike Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends two miles downstream of the dam. Within the possible damage zone are two dwellings, several farm buildings, a railroad track, and a marina. Those features lying within the downstream damage zone as reported by the St. Louis District, Corps of Engineers, were verified by the inspection team.

e. Ownership. The lake and dam are owned by Mr. Richard P. Norden. Mr. Norden's address is 13 Warwick Drive, St. Charles, Missouri, 63301.

f. Purpose of Dam. The dam impounds water for recreational use by the Owner and his guests.

g. Design and Construction History. According to Mr. Norden, the dam was constructed in 1965, and the builder of the dam was the Glosier Construction Co. of St. Charles, Missouri. Mr. Norden also reported that engineering assistance for the design and construction of the dam was provided by the U. S. Department of Agriculture, Soil Conservation Service. According to Mr. Les Volmert, District Conservationist, Soil Conservation Service, SCS did provide technical assistance; however, records of the design are no longer available. The extent of the engineering investigations performed for design of the dam are unknown.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacities of the drop inlet type spillway and the overflow type emergency spillway.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is essentially in a native state covered with timber. The watershed above the dam amounts to approximately 321 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 45 cfs* (W.S.Elev.548.3)
(2) Spillway capacity
  a. Principal ... 11 cfs (W.S. Elev. 547.8)
  b. Principal + emergency ... 372 cfs (W.S. Elev. 550.1)

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on topographic data shown on the 1972 Labadie, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 546.1
(2) Normal pool ... 546.0
(3) Spillway crest
  a. Principal ... 546.0
  b. Emergency ... 547.8
(4) Maximum experienced pool ... 548.3*
(5) Top of Dam ... 550.1 (min.)
(6) Streambed at centerline of dam ... 515±
(7) Maximum tailwater ... Unknown
(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 546.0) ... 1,400 ft.
(2) Length at maximum pool (Elev. 550.1) ... 1,600 ft.

* Based on an estimate of depth of flow at emergency spillway as observed by the Owner.

e. Storage.

(1) Normal pool ... 183 ac. ft.
(2) Top of dam (incremental) ... 94 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 21 acres
(2) Top of dam (incremental) ... 4 acres

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier, to the top of the dam.

(1) Type ... Earthfill, core wall*
(2) Length ... 710 ft.
(3) Height ... 40 ft.
(4) Top width ... 12 ft.
(5) Side slopes
    a. Upstream ... 1v on 2.8h (above waterline)
    b. Downstream ... 1v on 2.2h
(6) Cutoff ... Core trench*
(7) Slope protection
    a. Upstream ... Grass, wave berm
    b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, drop inlet, 18-inch diameter steel pipe
(2) Location ... Sta. 1 + 22, 27 feet upstream
(3) Elevation ... 546.0
(4) Outlet pipe ... 12-inch diameter steel pipe

*Per dam builder

i. Emergency Spillway.

(1) Type ... Uncontrolled, excavated earth, trapezoidal section

(2) Location ... Left abutment

(3) Crest ... Elevation 547.8

(4) Approach channel ... Lake

(5) Exit channel ... Trapezoidal earth section, 280 feet long

j. Lake Drawdown Facility ... None provided

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

According to Mr. Les Volmert, District Conservationist for the U.S. Department of Agriculture, Soil Conservation Service, technical assistance for design of the dam was provided by the Soil Conservation Service. However, records of the design are no longer available.

2.2 CONSTRUCTION

No formal records were maintained during construction of the dam. As previously stated, Klondike Lake Dam was constructed in 1965 by the Glosier Construction Company of St. Charles, Missouri. An interview with Mr. Gene Glosier of Glosier Construction Company indicated that a core trench, approximately 12 feet wide, was excavated about 8 feet deep to rock. The Contractor also stated that the dam was "keyed" into the rock at the south or right abutment. Mr. Glosier reported that fill for the dam was obtained from the area to be occupied by the lake and from the hillside to the north of the lake and was placed with the most impervious materials in the core of the dam, and compacted with sheepsfoot rollers. Mr. Glosier also mentioned that two 4-foot square steel anti-seepage collars were welded to the spillway outlet pipe.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the crest of the drop inlet type principal spillway. An emergency spillway, with a crest elevation approximately 1.8 feet higher than the crest of the principal spillway and about 2.3 feet lower than the top of the dam at its lowest point, is located at the left abutment. The Owner reported that the dam has never been overtopped and that the highest lake level observed occurred in April, 1979 when the depth of flow at the emergency spillway was estimated to be about 6 inches.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillways were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Klondike Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 24 April 1980. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection, was the area below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on Pages A-1 through A-5 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Area Geology. The Klondike Dam is located in the valley of a small unnamed stream which is a tributary to the Missouri River, approximately one mile to the east. The area is within the Salem Plateau Section of the Ozark Plateaus Physiographic Province near the border with the Dissected Till Plains Section of the Central Lowlands Province. The topography is moderately rugged, and there is approximately 250-300 feet of relief between the reservoir and the surrounding drainage divides. The bedrock formations consist of gently northward dipping Ordovician-age sedimentary strata of the Jefferson City-Cotter dolomite and St. Peter sandstone formations. The dam is situated on Jefferson City-Cotter dolomite, whereas the reservoir and drainage basin are underlain mostly by St. Peter sandstones. No faulting was observed or has been reported in the vicinity of the site.

The Jefferson City-Cotter dolomite is a light brown medium-to-finely crystalline dolomite or argillaceous dolomite. It is thin-to-medium bedded, often argillaceous, and cherty. Solution enlargement of joints and bedding planes frequently occurs in the dolomite, and the contact between bedrock and the overlying surficial materials is usually an irregular surface. Jefferson City-Cotter dolomites outcrop in the main stream channel immediately downstream from the toe of the embankment. The St. Peter sandstone is a

white, fine-to-medium-grained pure quartz sandstone. It is quarried nearby. It generally is massively bedded and, although loosely cemented, exposed rock surfaces usually are case hardened by weathering processes. The St. Peter sandstone outcrops above both abutments and in stream channels around the reservoir.

The unconsolidated surficial materials are composed principally of soils of the Winfield Series. This series consists of deep, well-drained soils derived from the wind deposited silts on the uplands adjacent to the Missouri River Valley. They are a light brown silt in the upper layers, becoming darker and more clayey with depth. The soils are classified as CL or CL-ML materials, are moderately permeable and susceptible to erosion, but generally suited for embankments and water impoundments.

There appear to be no significant geotechnical problems at the Klondike Lake site, and no adverse geologic conditions were observed that would be considered conducive to severe reservoir leakage or embankment instability.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) were examined and appeared to be in sound condition, although erosion of the unprotected upstream slope has created a near vertical face about 6-to-12 inches high at the normal pool waterline at locations where the wave berm is submerged. No cracking of the surface, sloughing of the embankment slopes, or undue settlement of the dam crest was evident. The downstream slope and the upstream slope above normal pool level were well covered by a thick stand of fescue type grass that was about 12 inches high at the time of the inspection. Near the waterline, the upstream face was covered with brush and trees up to 3 inches in diameter. Numerous small trees and some undergrowth also existed on the downstream face of the dam. Fescue type grass about 6 inches high covered the crest of the dam. A V-shaped gully about 18 inches deep had been eroded into the downstream slope of the embankment near the right abutment apparently by stormwater runoff. Examination of a soil sample obtained from the downstream face of the embankment indicated the surficial material to be a lean clay (CL) of low-to-medium plasticity.

A marshy area (see Photo 10) as evidenced by cattails and standing and flowing water, was observed downstream of the the toe of the dam. It appeared that most of the water within the marsh was discharged to the area by a spring located downstream of the dam. Flow from the spring was estimated to be less than 2 gpm. Although there was no visible flow, the soil in the area between the downstream toe of the dam and the spring outlet (see Photo 9) was soft and damp. Some minor seepage was also evident along the right abutment, with water flowing from an area located about one-third of the distance between the downstream toe and the crest of the dam. The flow appeared to be less than 0.5 gpm.

The drop inlet spillway (see Photo 3) appeared to be in sound condition; however, there was a substantial growth of weeds and brush growing near the inlet pipe. The spillway outlet pipe (see Photo 4) where visible also appeared to be in good condition. There was no evidence of seepage in the area immediately surrounding the downstream end of the outlet pipe.

The emergency spillway channel, including the crest area and outlet channel (see Photos 5 and 6) appeared to be in sound condition, with the exception of one portion of the right bank of the outlet channel near the dam (see Photos 7 and 8) which was eroded. Except for the eroded area, the spillway channel was well covered with fescue type grass.

d. Downstream Channel. The channel downstream of the dam is unimproved. Near the dam the stream channel was cluttered with brush and fallen trees.

e. Reservoir. The hillsides surrounding the lake are covered with forest vegetation or dense grass. The shoreline is grass covered or tree lined. The amount of sediment within the lake could not be determined at the time of the inspections; however, due to the surrounding vegetation, it is expected not to be significant.

3.2 EVALUATION

The deficiencies observed during this inspection and noted herein are not considered significant to warrant immediate remedial action

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillways are uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacities of the uncontrolled principal and emergency spillways.

4.2 MAINTENANCE OF DAM

The embankment and areas immediately adjacent thereto appeared as if they receive periodic maintenance. Apparently, trees and brush are not always removed from the slopes since their presence was noted during the inspection. It also appears that no attempt has been made to restore the eroded area of the emergency spillway outlet channel.

According to Mr. Richard Norden, Owner of the lake and dam, grouting operations were performed about 1968 on the dam to reduce the flow of water under the dam. The Owner reported that after construction of the lake, the flow from the spring located downstream of the dam, (see Plate 3), increased considerably. The grout was placed in a rock formation that exists approximately 60 feet below the top of the dam and according to Mr. Norden, the operation significantly reduced the flow from the spring.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilties requiring operation exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Lack of or inadequate maintenance is considered detrimental to the safety of the dam. It is recommended that maintenance of the dam and spillways be undertaken on a regular basis and that records be kept of all major items of maintenance work performed. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were developed from the 1972 USGS Labadie, Missouri, Quadrangle Map. The proportions and dimensions of the spillways and dam were developed from surveys made during the inspection. Records of rainfall, streamflow or flood data for the watershed are not available.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends two miles downstream of the dam.

c. Visual Observations.

(1) The principal spillway is a drop inlet type located to the right of the center of the dam. The 18-inch steel pipe drop inlet is about 8 feet deep. A wire fence about the pipe serves as a trash screen.

(2) A 12-inch steel outlet pipe extends from the drop inlet spillway to the toe of the dam at the downstream channel.

(3) The emergency spillway, a shallow broad-crested trapezoidal section, is located in the gently sloping hillside of the left (north) abutment.

(4) An earthen bank on the right side of the channel joins the dam and serves to confine flow to the channel. A section of the bank below the downstream side of the crest of the dam has been eroded and spillway releases can escape the channel.

(5) The original stream channel abuts the dam.

d. Overtopping Potential. The spillways (principal and emergency) are inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The results of the dam overtopping analysis are as follows:

(Note: The data appearing in the following table have been extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Dam (Elev. 550.1)	Duration of Overtopping of Dam (Hrs.)
0.50	1,903	552.2	2.1	4.3
1.00	5,231	553.3	3.2	6.9

Elevation 550.1 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping amounts to approximately 372 cfs, which is the routed outflow corresponding to about 20 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 3.2 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a lean clay of low-to-medium plasticity) to that used to construct this dam have shown evidence that the material under certain conditions such as high velocity flow, can be very erodible. An example of such erosion is apparent at the emergency spillway. Such a condition exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of flow over the dam crest, a maximum of 3.2 feet, and the duration of flow over the dam, 6.9 hours, are substantial, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable; however, there is a possibility that they could result in failure by erosion of the dam.

f. Reference. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillways and dam crest are presented on Pages B-1 through B-3 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year freqency flood are shown on pages B-4 through B-6. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-7 through B-11; tabulation of lake surface area, elevation and storage volume is shown on page B-12 and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-12.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam. According to the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. With the exception of pressure grouting in 1968 to reduce dam underseepage, the Owner reported that no post construction changes have been made or have occurred which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic area. An earthquake of this magnitude would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the spillways (principal plus emergency) are capable of passing lake outflow of about 372 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of probable maximum flood magnitude, the lake outflow would be about 5,231 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 32 cfs.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include trees and brush on the slopes of the embankment, seepage, the areas of erosion, and the lack of adequate slope protection to prevent erosion of the upstream face of the dam.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacities of the spillways were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a, should be accomplished within a reasonable time. However, it is recommended that restoration of the eroded bank of the emergency spillway outlet channel and the item recommended in paragraph 7.2 regarding gaining additional spillway capacity be pursued on a high priority basis.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic area. An earthquake of this magnitude would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of probable maximum flood magnitude.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Provide some means of controlling seepage evident in the area adjacent to the downstream toe near the center of the dam and at the junction of the embankment and the right abutment. Uncontrolled seepage can lead to a piping condition which could result in the failure of the dam. Drainage of the areas affected by seepage including elimination of the marshy area just downstream of the dam should be one of the objectives of the seepage control measures since saturation of the soil weakens the foundation which could impair the stability of the dam.

(2) Restore the eroded bank of the emergency spillway channel and provide some form of protection in order to prevent future erosion by lake outflow or overland drainage. Damage by unconfined spillway releases to the dam and to other areas downstream of the dam can occur during periods when flow passes the emergency spillway.

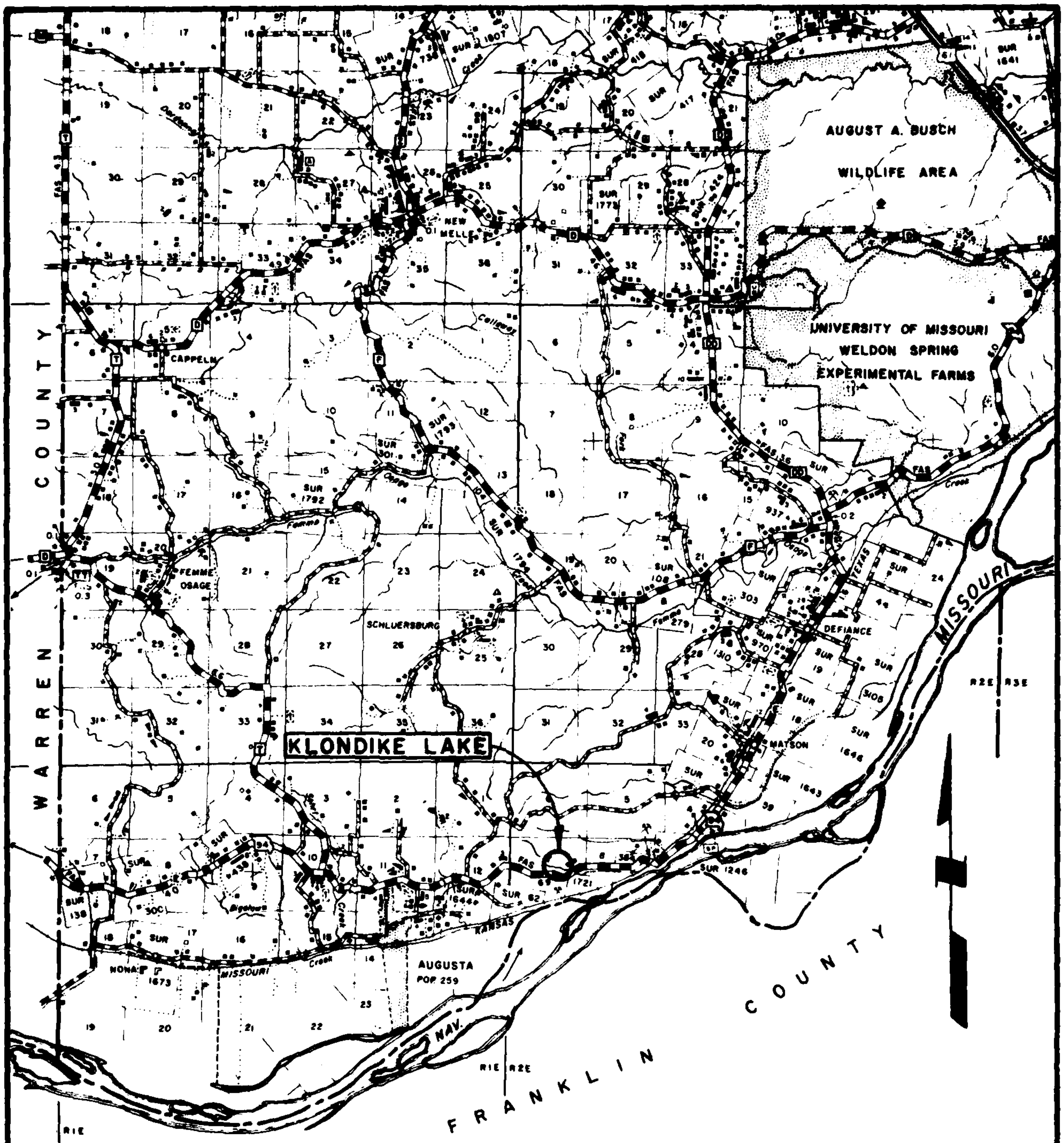
(3) Provide some form of protection other than grass for the upstream face of the dam at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion of the embankment by wave action or by a fluctuating lake level.

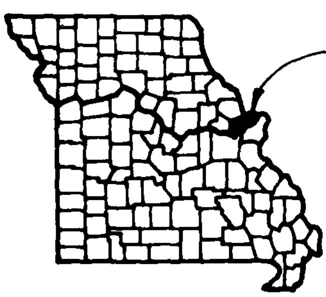
(4) Restore the eroded areas of the dam and provide some means of preventing future erosion by overland drainage. Loss of material due to erosion can impair the structural stability of the dam.

(5) Remove all trees and brush which may conceal animal burrows from the upstream and downstream slopes of the dam. Tree roots and animal burrows can provide a passageway for lake seepage which could lead to a piping condition (progressive internal erosion) and subsequent failure of the dam. The turf cover should be restored if destroyed or missing. Maintain the turf cover on the slopes at a height that will not hinder inspection of the slope or provide cover for burrowing animals.

(6) Provide maintenance of all areas of the dam and spillways on a regularly scheduled basis in order to insure features of being in satisfactory operational condtion.

(7) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.





LOCATION MAP

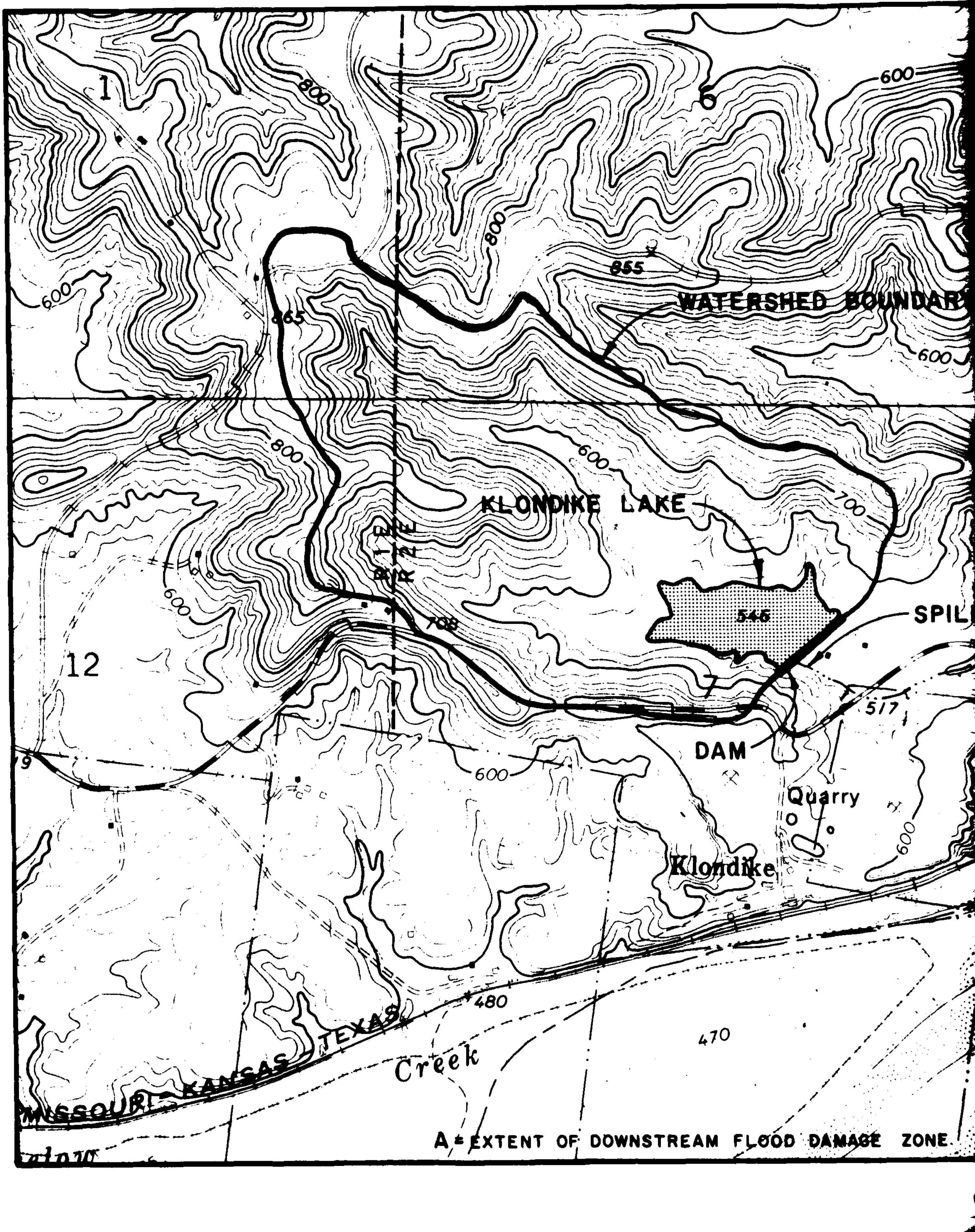
KLONDIKE LAKE

0 1 2 3 4

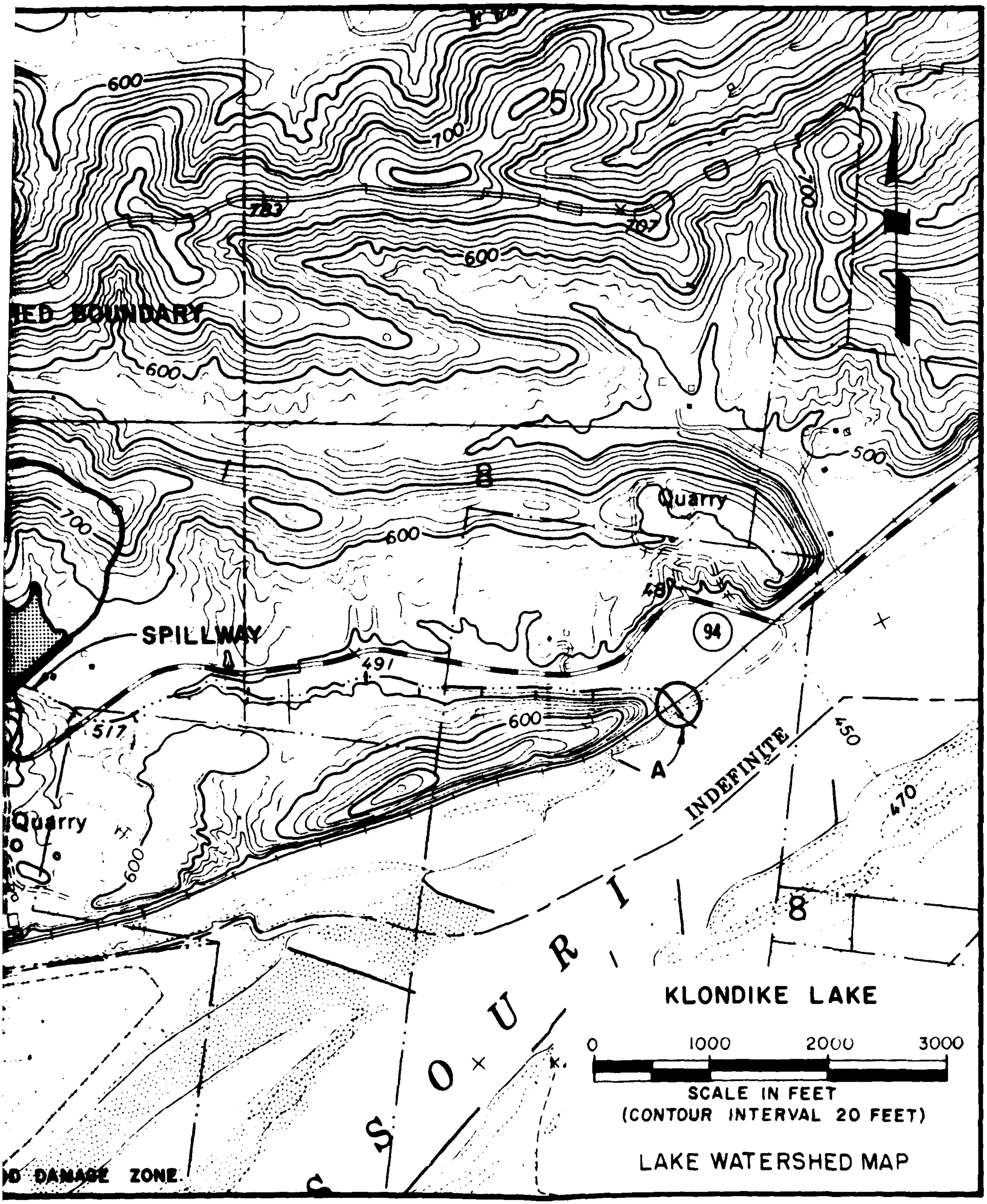
SCALE (MILES)

REGIONAL VICINITY MAP

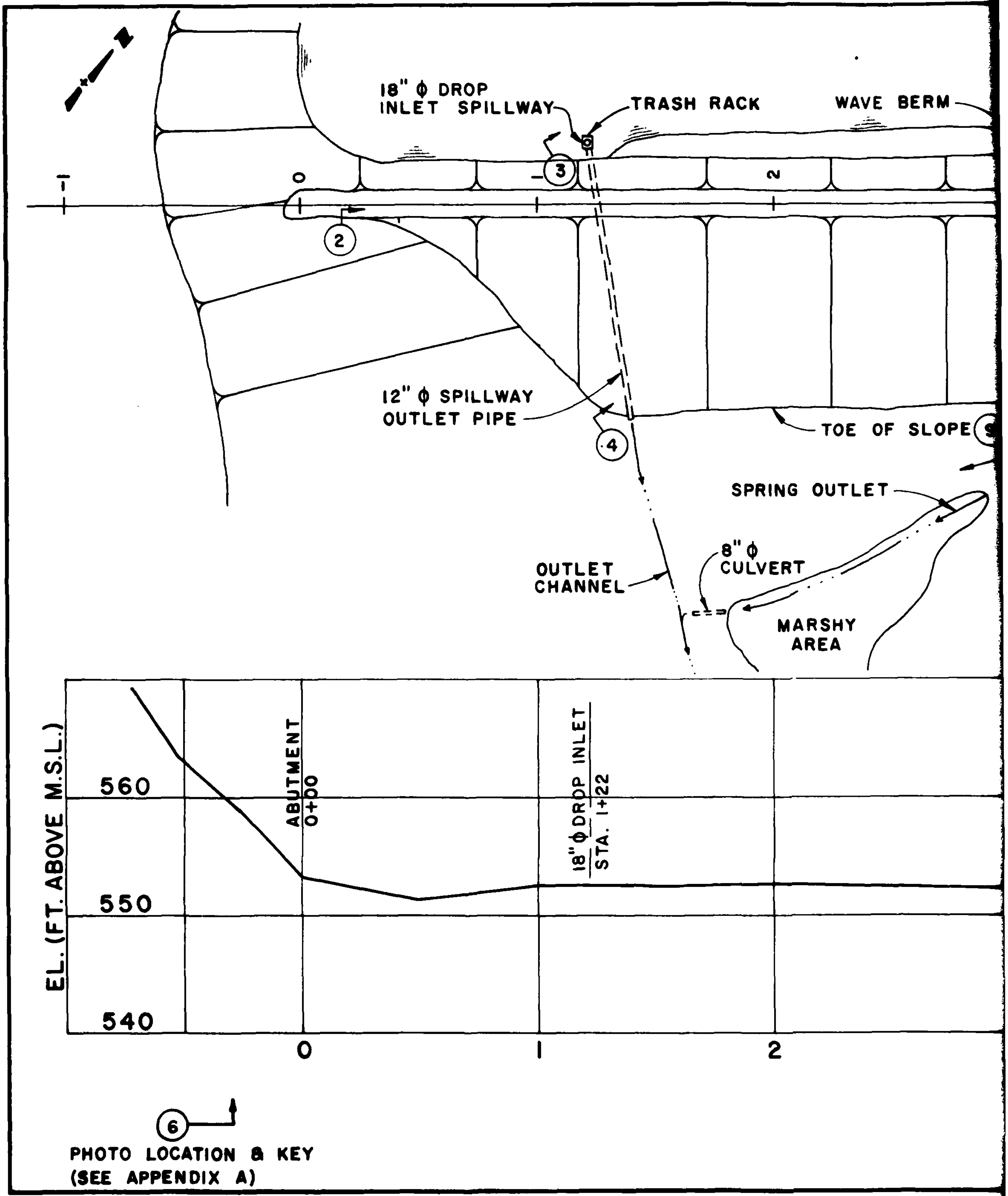
PLATE I



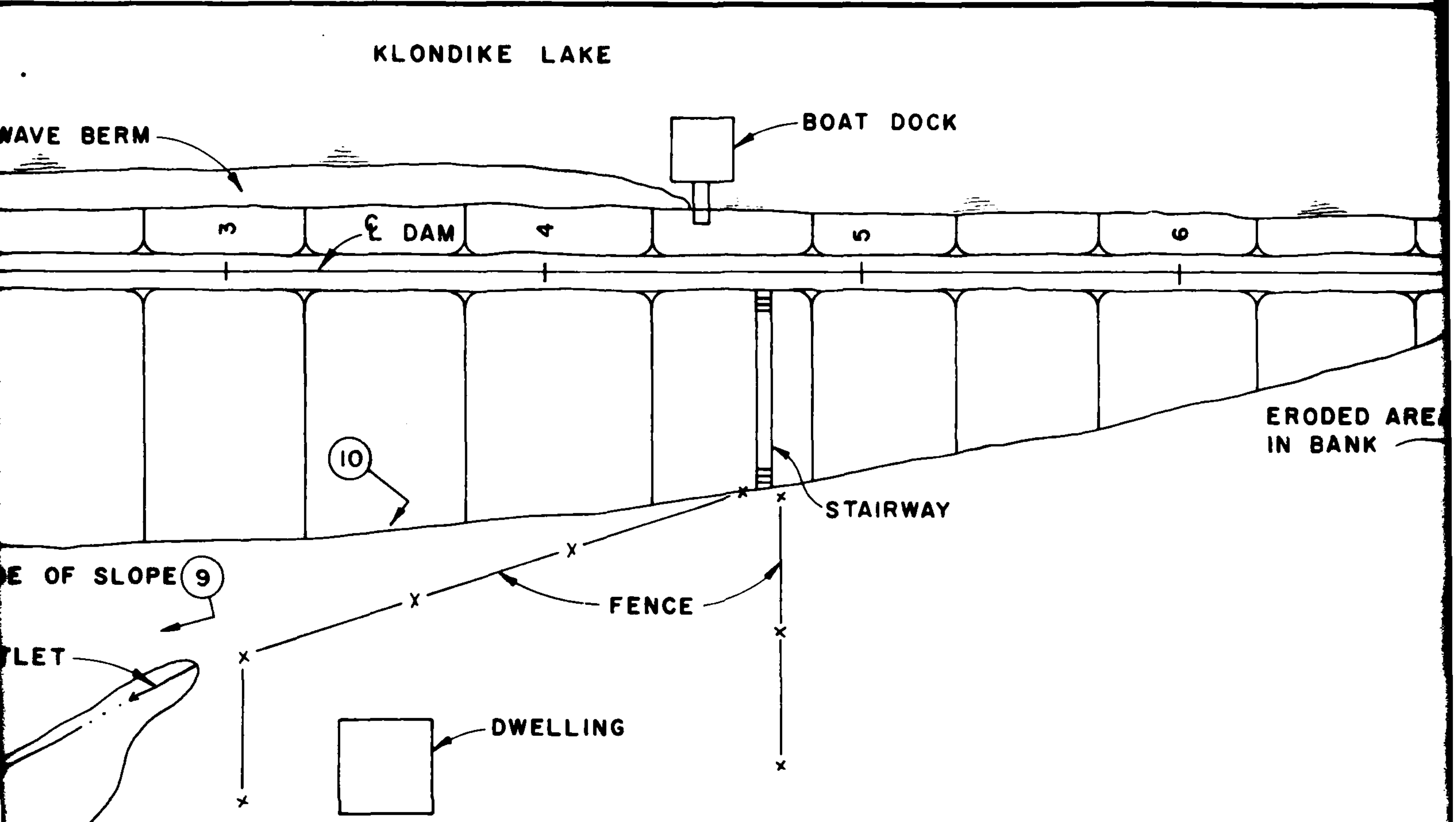
1
6
12
7
800
600
855
865
708
546
517
480
470
WATERSHED BOUNDARY
KLONDIKE LAKE
SPIL
DAM
Quarry
Klondike
MISSOURI - KANSAS - TEXAS
Creek
A = EXTENT OF DOWNSTREAM FLOOD DAMAGE ZONE.



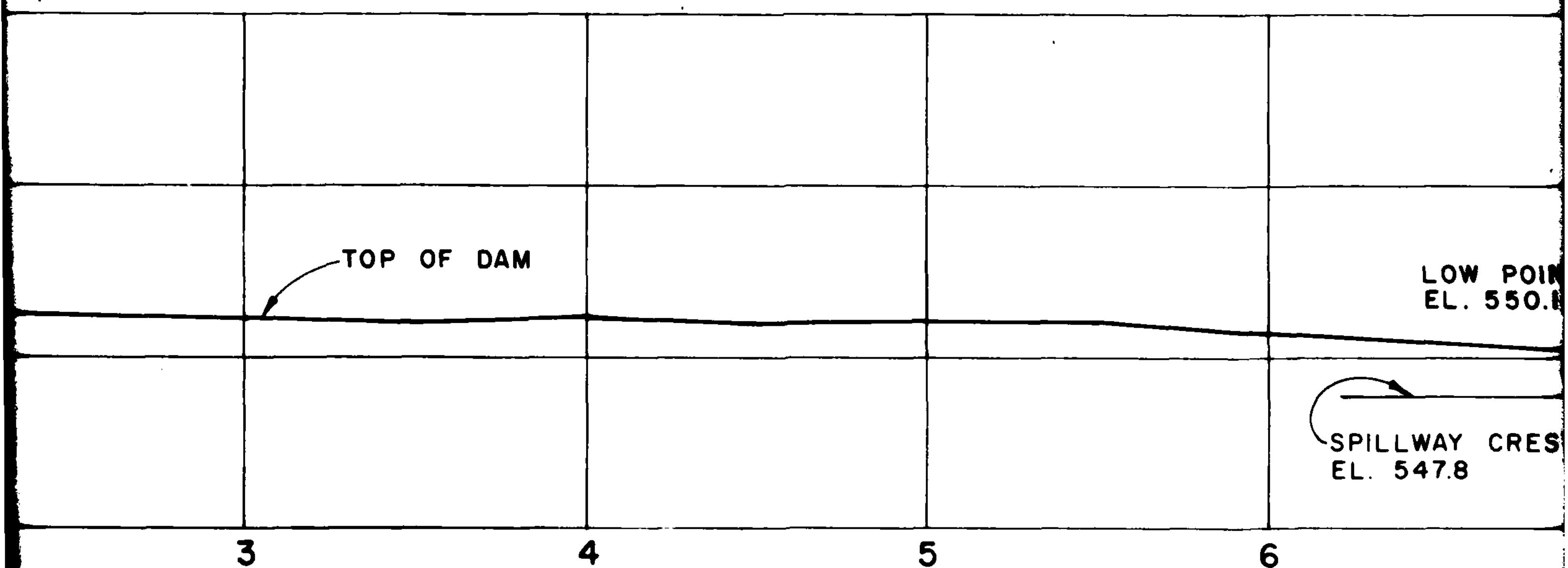
600
700
5
783
707
600
700
HED BOUNDARY
600
8
Quarry
600
700
500
480
SPILLWAY
94
491
517
600
A
450
INDEFINITE
470
Quarry
600
8
S O U R I
D DAMAGE ZONE
KLONDIKE LAKE
0 1000 2000 3000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP



18" Φ DROP INLET SPILLWAY
TRASH RACK
WAVE BERM
12" Φ SPILLWAY OUTLET PIPE
TOE OF SLOPE
SPRING OUTLET
8" Φ CULVERT
OUTLET CHANNEL
MARSHY AREA
ABUTMENT 0+00
18" Φ DROP INLET
STA. 1+22
EL. (FT. ABOVE M.S.L.)
560
550
540
0
1
2
PHOTO LOCATION & KEY
(SEE APPENDIX A)

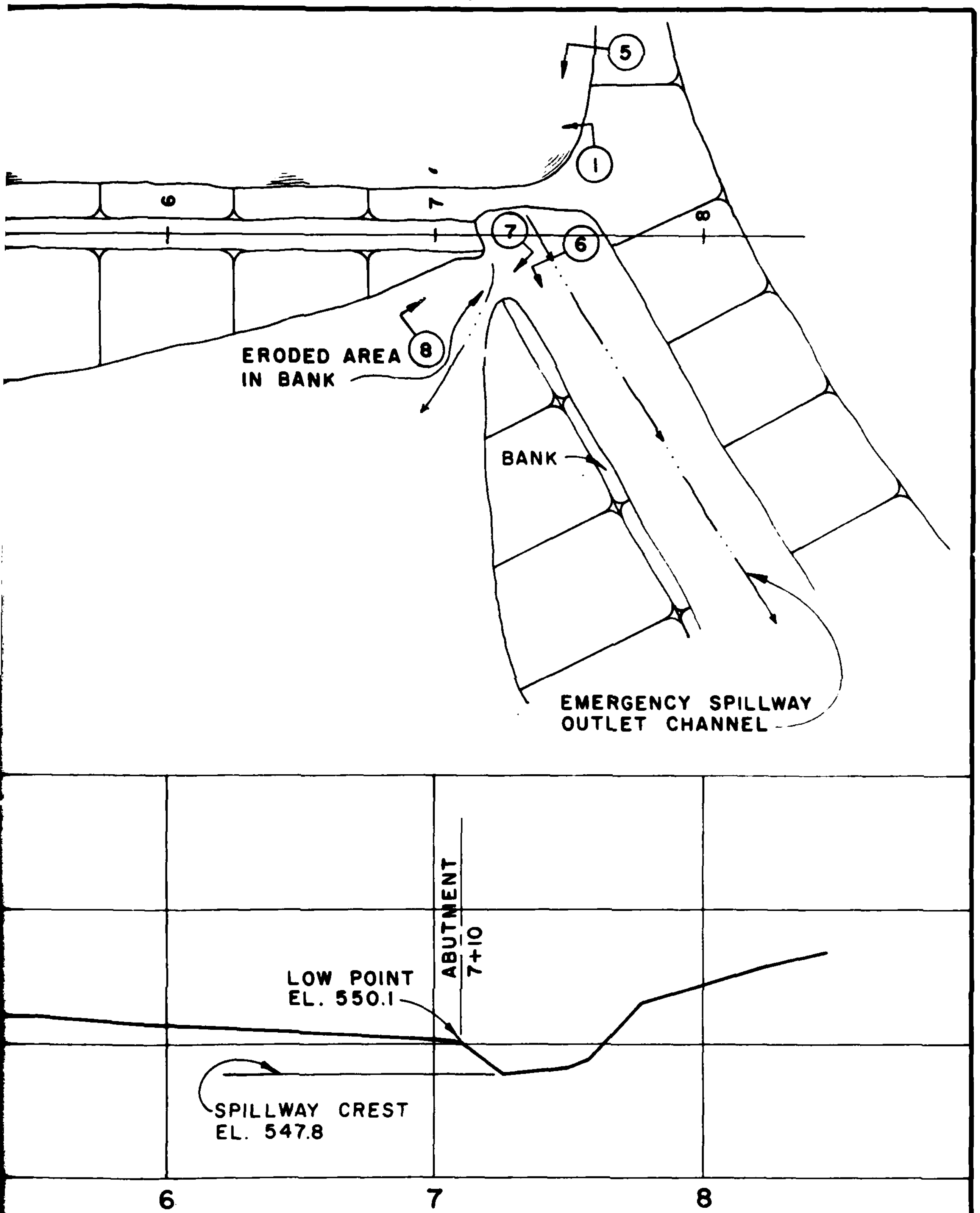


GENERAL PLAN OF DAM
SCALE: 1"=50'



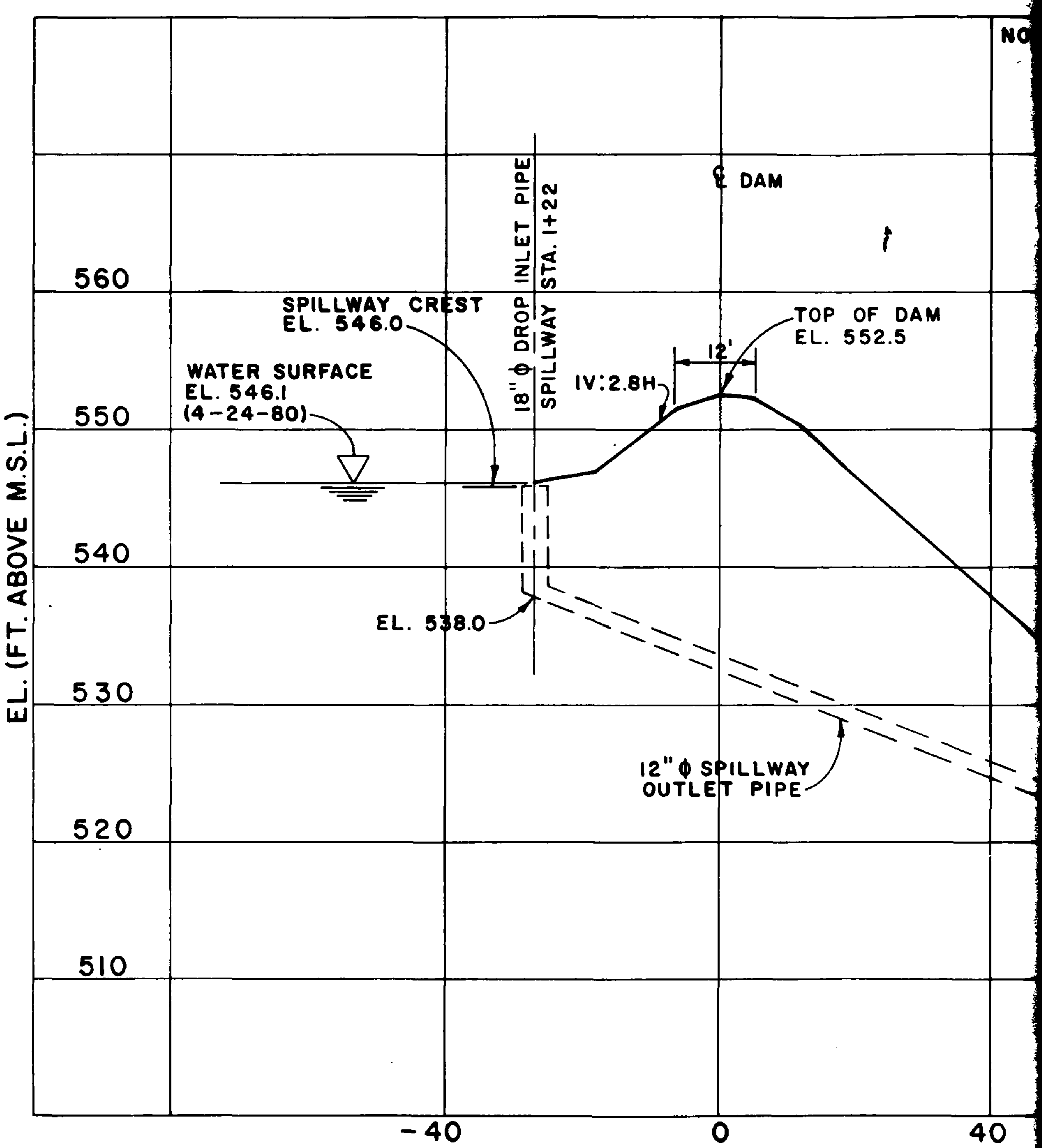
PROFILE DAM CREST
SCALES: 1"=10'V., 1"=50'H.

1 2



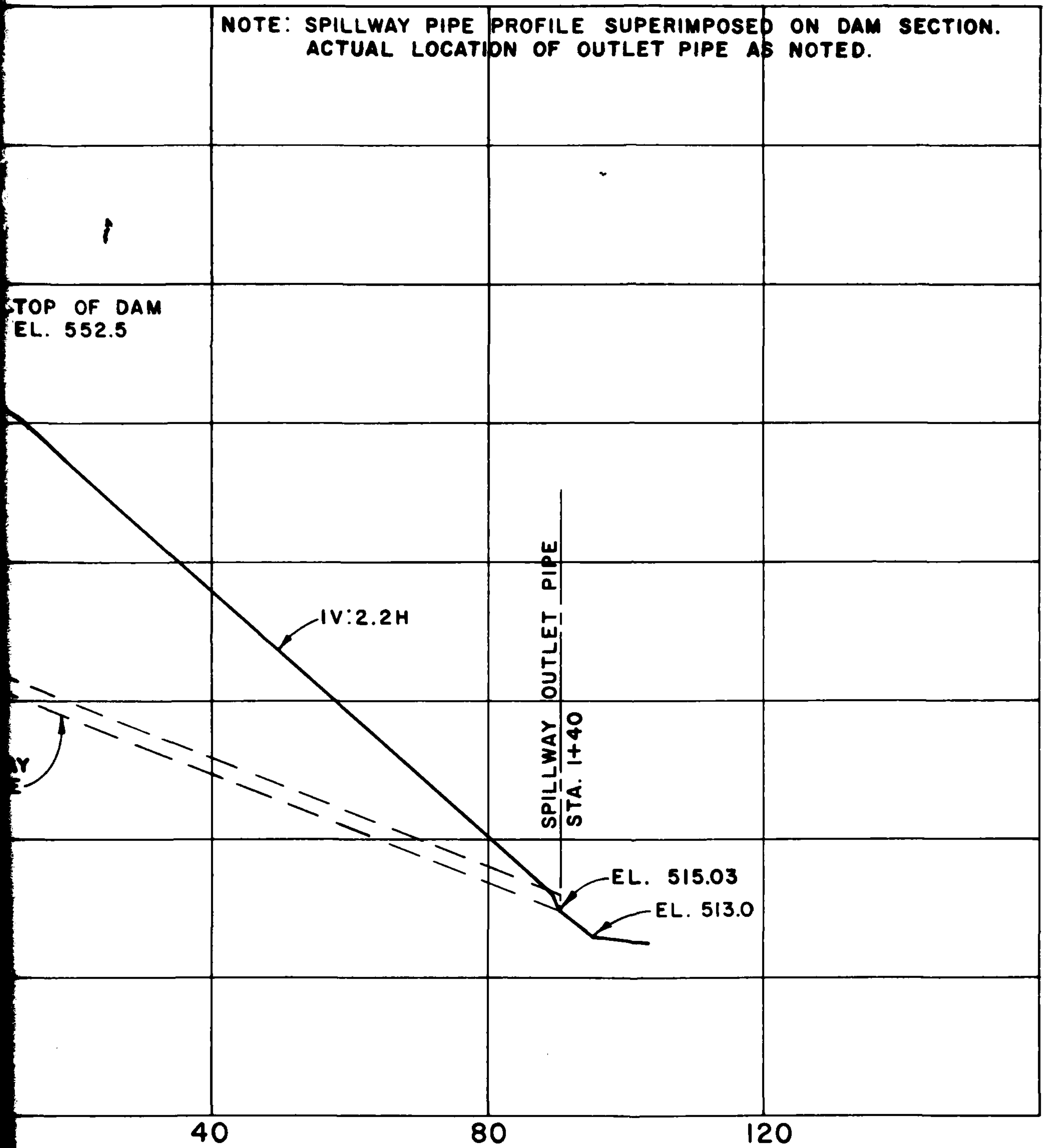
KLONDIKE LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. May 1980



DAM CROSS-SECTION STA. 1

SCALE: 1"=10' V., 1"=20' H.



-SECTION STA. 1+40

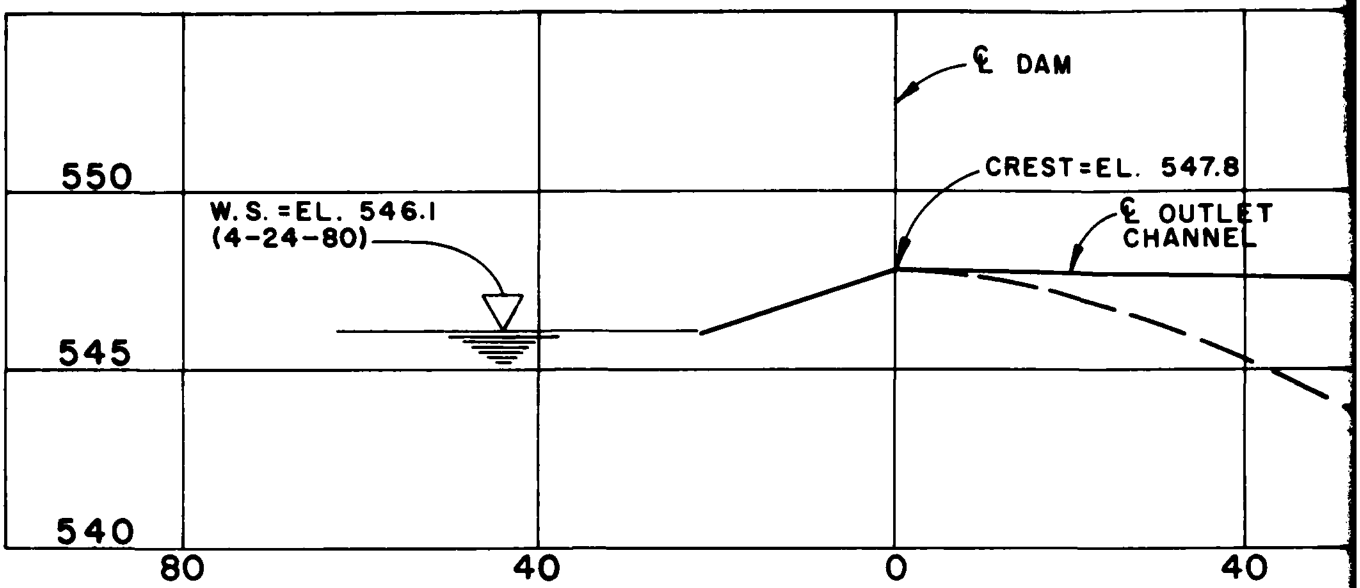
: 1"=10'V.,1"=20'H.

KLONDIKE LAKE
DAM CROSS-SECTION

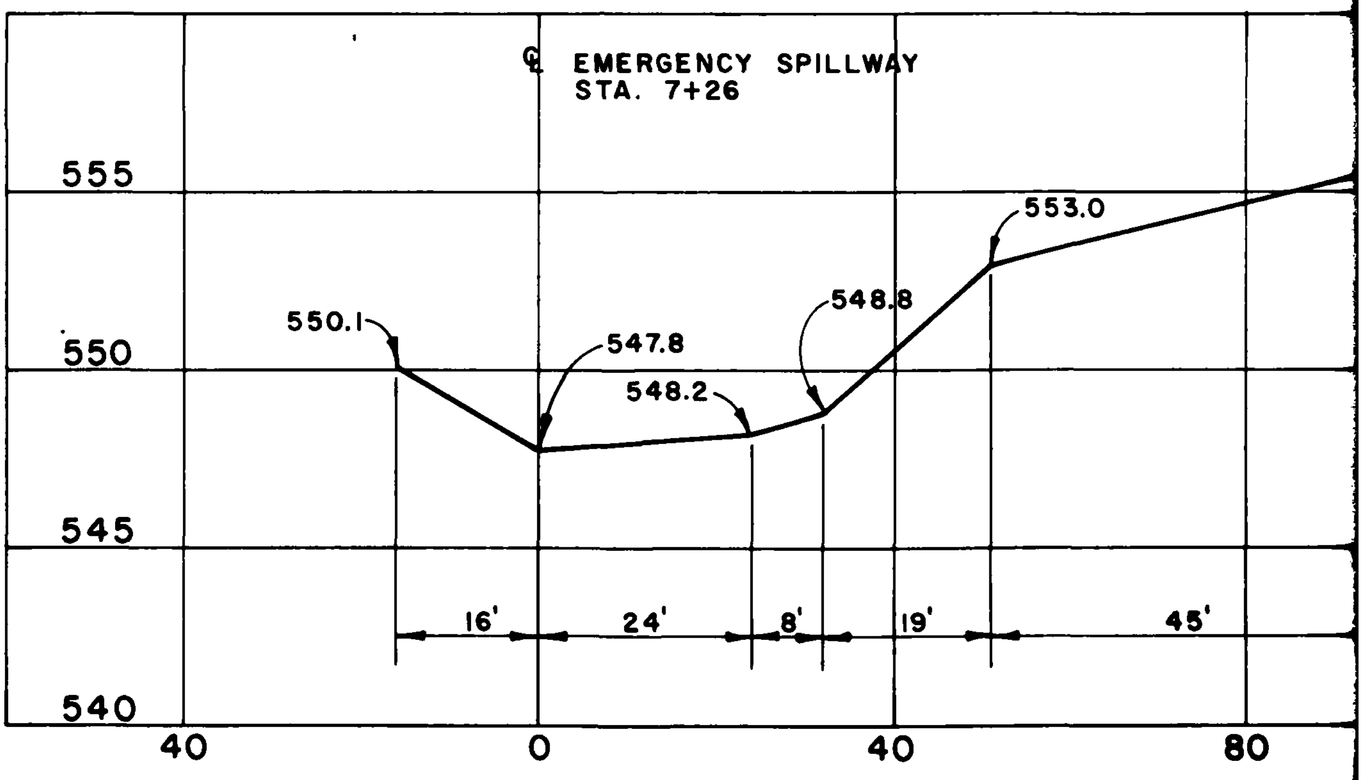
Horner & Shifrin, Inc. May 1980

12

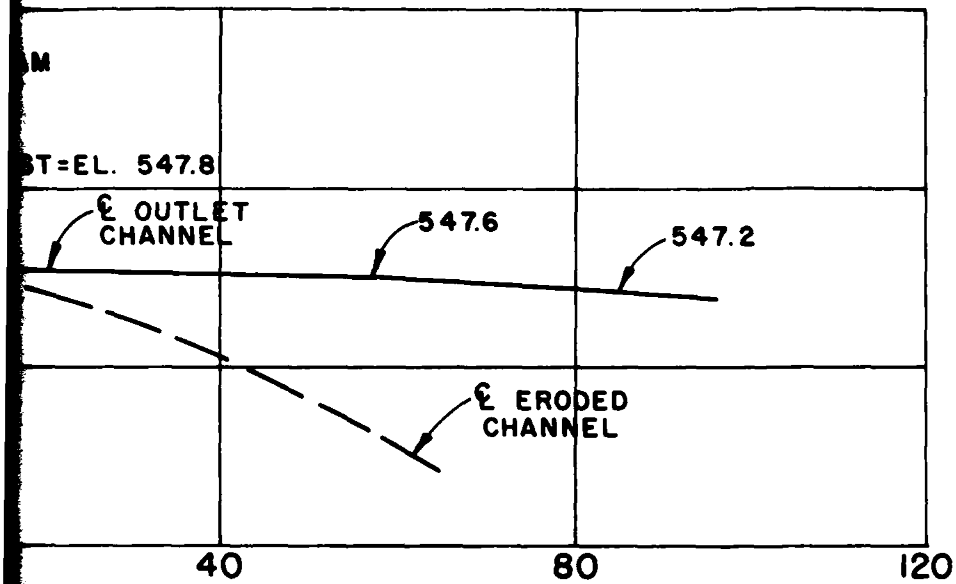
PLATE 4



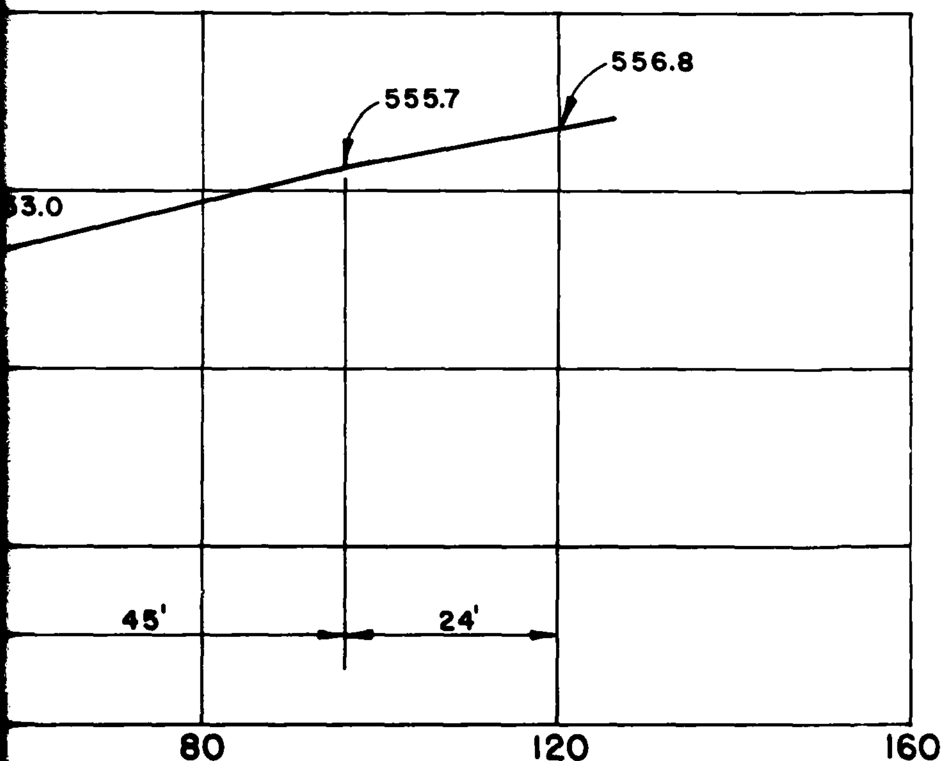
PROFILE EMERGENCY SPILLWAY
SCALES: 1"=5'V., 1"=20' H.



CROSS-SECTION AT CREST
SCALES: 1"=5'V., 1"=20' H.



Y SPILLWAY
1"=20' H.



AT CREST
1"=20' H.

KLONDIKE LAKE
EMERGENCY SPILLWAY
PROFILE & CROSS-SECTION
Horner & Shifrin, Inc. August. 1980

PLATE 5

APPENDIX A

INSPECTION PHOTOGRAPHS


NO. 1: UPSTREAM FACE OF DAM


NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: DROP INLET SPILLWAY

NO. 4: DOWNSTREAM END OF SPILLWAY PIPE

NO. 5: EMERGENCY SPILLWAY

NO. 6: EMERGENCY SPILLWAY OUTLET CHANNEL

NO. 7: ERODED BANK OF EMERGENCY SPILLWAY OUTLET CHANNEL

NO. 8: EROSION ADJACENT TO EMERGENCY SPILLWAY OUTLET CHANNEL

NO. 9: AREA ADJACENT TO DOWNSTREAM TOE OF DAM

NO. 10: MARSHY AREA DOWNSTREAM OF DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.5 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year flood) was provided by the St. Louis District, Corps of Engineers. Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to the occurrence of the PMF and probabilistic storm(s).

b. Drainage area = 0.502 square miles = 321 acres.

c. SCS parameters:

Time of Concentration (Tc) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.265 hours

Where: T_c = Travel time of water from hydraulically most distant point of interest, hours.

L = Length of longest watercourse = 0.947 miles.

H = Elevation difference = 319 feet.

The time of concentration (Tc) was obtained using method C as described in Fig. 30, "Design of Samll Dams", by the United States Department of the Interior Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Lag time = 0.159 hours (0.60 Tc)

Hydrologic Soil Group = B (Winfield Series, per SCS Soil Survey Report)

Soil type CN = 60 (AMC II, 100-yr flood condition)
= 78 (AMC III, PMF condition)

2. Spillway releases for the drop inlet spillway were computed utilizing equations and nomographs presented in "Design of Small Dams" by the U. S. Department of the Interior (USDI) for drop inlet type spillways. The rise of the nappe above the elevation of the crest lip was considered negligible. The following equation was used for crest control:

$$Q = C_o \,(2\, R_s)\, H_o^{\,3/2}$$

where "C_o" is a coefficient obtained from Figure 283 of the above reference, expressed in terms of H_o/R_s, "R_s" is the radius, 0.75 feet, of the spillway crest, "H_o" is the depth of flow over the crest.

When the ratio H_o/R_s reached a value of 1.00, inflow was determined by assuming flow was over a sharp edge submerged orifice. The following equation was used: $Q = Ca\,(2gh)^{0.5}$, where "C" is a coefficient assumed to be 0.6, "a" is the area of the orifice, 1.767 sf, "h" is the height of flow above the orifice, and "g" is acceleration due to gravity. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 4-3.

Flow through the 12-inch diameter outlet pipe was determined using Bernoulli's equation for pressure flow in pipes. Losses, including throat, entrance, pipe and exit losses totaled 5.46 velocity heads. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, pages 8-5 and 8-6.

Discharge quantities, determined by the methods described herein were plotted versus corresponding lake water surface elevations to determine the discharge rating curve for the drop inlet spillway.

3. The emergency spillway section consists of a broad-crested, trapezoidal section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth Q_c was computed as $Q_c = (\frac{a^3 g}{t})^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 8-7.

c. Static lake levels corresponding to the various values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignifcant friction losses across the length of the spillway.

d. The discharges for the principal and emergency spillways for equal elevations were summated for entry on the Y4 and Y5 cards.

4. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and $V cards. The program assumes that flow over the dam crest occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow passing the spillways as entered on the Y4 and Y5 cards.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{v^2}{2g}$

```
A1      ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF KLONDIKE LAKE DAM
A3      RATIOS OF PMF ROUTED THROUGH RESERVOIR
B      288       0       5       0       0       0       0       0       0       0
B1       5
J        1       3       1
JI    0.20    0.50    1.00
K        0  INFLOW                                       1
K1      INFLOW HYDROGRAPH
M        1       2   0.502                     1.0                       1
P        0    25.5     102     120     130
T                                                       -1     -78
W2               0.159
X     -1.0    -.10     2.0
K        1     DAM                                       1
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1       1                                          182.87      -1
Y4   546.0   546.5   547.0   547.8   548.8   549.5   550.5   551.5   552.5   553.5
Y4   554.5   555.5   556.5   557.5
Y5       0     4.8     7.6    11.4      79     202     485     875    1360    1940
Y5    2611    3386    4321    5486
$A       0    21.1    24.6    33.1    43.5    55.1
$E     520     546     550     560     570     580
$$   546.0
$D   550.1
$L       0      10     102     197     253     498     530     693     710     763
$V   550.1   550.3   551.3   552.0   552.1   552.3   552.4   552.6   553.3   563.4
K       99
```

```
1A1      ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF KLONDIKE LAKE DAM
A3       100-YR FLOOD ROUTED THROUGH RESERVOIR
B      288       0       5                                          4
B1       5
J        1       1       1
J1    1.00
K        0  INFLOW                                      1
K1       INFLOW HYDROGRAPH
M        0       2   0.502                      1.0                 1
O      288   6.974
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .023    .023
O1    .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
O1    .023    .023    .023    .023    .023    .023    .030    .030    .030    .030
O1    .030    .030    .048    .048    .048    .049    .049    .049    .134    .134
O1    .134    .255    .255    .546    .817    .380    .255    .134    .134    .134
O1    .049    .049    .049    .048    .048    .048    .030    .030    .030    .030
O1    .030    .030    .023    .023    .023    .023    .023    .023    .023    .023
O1    .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .077    .007    .007    .007
T                                                -1     -60
W2           0.159
X     -1.0    -.10     2.0
K        1     DAM                                      1
```

100-YR. FLOOD (con't.)

```
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                    1       1
Y1     1                                                 182.87      -1
Y4 546.0     546.5   547.0   547.8   548.8   549.5   550.5   551.5   552.5   553.5
Y4 554.5     555.5   556.5   557.5
Y5     0       4.8     7.6    11.4      79     202     485     875    1360    1940
Y5  2611      3386    4321    5486
$A     0      21.1    24.6    33.1    43.5    55.1
$E   520       546     550     560     570     580
$$ 546.0
$D 550.1
$L     0        10     102     197     253     498     530     693     710     763
$V 550.1     550.3   551.3   552.0   552.1   552.3   552.4   552.6   553.3   563.4
K     99
```

```
ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF KLONDIKE LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

                          JOB SPECIFICATION
   NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
  288       0       5       0       0       0       0       0       0       0
                        JOPER     NWT   LROPT   TRACE
                            5       0       0       0

                 MULTI-PLAN ANALYSES TO BE PERFORMED
                     NPLAN= 1 NRTIO= 3 LRTIO= 1
  RTIOS=    .20    .50   1.00


**********        **********        **********        **********        **********

                        SUB-AREA RUNOFF COMPUTATION

  INFLOW HYDROGRAPH

             ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
            INFLOW       0       0       0       0       0       1       0       0

                              HYDROGRAPH DATA
  IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
      1       2     .50    0.00     .50    1.00   0.000       0       1       0

                               PRECIP DATA
             SPFE     PMS      R6     R12     R24     R48     R72     R96
             0.00   25.50  102.00  120.00  130.00    0.00    0.00    0.00

                                LOSS DATA
 LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
     0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -78.00    0.00    0.00

   CURVE NO =  -78.00  WETNESS =   -1.00  EFFECT CN =   78.00

                           UNIT HYDROGRAPH DATA
                         TC=  0.00     LAG=   .16

                              RECESSION DATA
                  STRTQ=   -1.00    QRCSN=    -.10    RTIOR= 2.00

   TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

   UNIT HYDROGRAPH 12 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .16  VOL= 1.00
  407.     1155.     1094.      608.      307.      157.       79.       41.       21.       11.
    5.        0.
```

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.22	.19	.03	270.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.22	.19	.03	425.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.22	.19	.02	575.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.22	.19	.02	660.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.22	.19	.02	705.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.22	.20	.02	730.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.22	.20	.02	745.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.22	.20	.02	755.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.22	.20	.02	761.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.22	.20	.02	766.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.22	.20	.02	770.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.22	.20	.02	774.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.24	.02	793.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.24	.02	842.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.24	.02	889.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.24	.02	917.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.24	.02	932.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.01	942.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.25	.01	948.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.26	.25	.01	952.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.26	.25	.01	955.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.26	.25	.01	958.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.26	.25	.01	960.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.26	.25	.01	962.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.33	.31	.01	989.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.33	.31	.01	1063.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.33	.31	.01	1134.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.33	.31	.01	1174.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.33	.31	.01	1195.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.33	.31	.01	1207.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.33	.31	.01	1214.
1.01	2.40	32	.01	0.00	.01	0.	1.01	14.40	176	.33	.32	.01	1218.
1.01	2.45	33	.01	0.00	.01	0.	1.01	14.45	177	.33	.32	.01	1221.
1.01	2.50	34	.01	0.00	.01	0.	1.01	14.50	178	.33	.32	.01	1223.
1.01	2.55	35	.01	0.00	.01	0.	1.01	14.55	179	.33	.32	.01	1225.
1.01	3.00	36	.01	0.00	.01	0.	1.01	15.00	180	.33	.32	.01	1227.
1.01	3.05	37	.01	0.00	.01	0.	1.01	15.05	181	.20	.19	.01	1178.
1.01	3.10	38	.01	0.00	.01	0.	1.01	15.10	182	.40	.39	.01	1114.
1.01	3.15	39	.01	0.00	.01	0.	1.01	15.15	183	.40	.39	.01	1202.
1.01	3.20	40	.01	.00	.01	0.	1.01	15.20	184	.59	.58	.01	1417.
1.01	3.25	41	.01	.00	.01	0.	1.01	15.25	185	.69	.68	.01	1761.
1.01	3.30	42	.01	.00	.01	0.	1.01	15.30	186	1.68	1.65	.03	2521.
1.01	3.35	43	.01	.00	.01	1.	1.01	15.35	187	2.77	2.73	.04	4327.
1.01	3.40	44	.01	.00	.01	1.	1.01	15.40	188	1.09	1.07	.01	6089.
1.01	3.45	45	.01	.00	.01	1.	1.01	15.45	189	.69	.68	.01	5856.

PMF END-OF-PERIOD FLOW

1.01	3.50	46	.01	.00	.01	2.	1.01	15.50	190	.59	.59	.01	4545.
1.01	3.55	47	.01	.00	.01	2.	1.01	15.55	191	.40	.39	.00	3422.
1.01	4.00	48	.01	.00	.01	3.	1.01	16.00	192	.40	.39	.00	2601.
1.01	4.05	49	.01	.00	.01	3.	1.01	16.05	193	.30	.30	.00	2042.
1.01	4.10	50	.01	.00	.01	4.	1.01	16.10	194	.30	.30	.00	1662.
1.01	4.15	51	.01	.00	.01	4.	1.01	16.15	195	.30	.30	.00	1423.
1.01	4.20	52	.01	.00	.01	5.	1.01	16.20	196	.30	.30	.00	1297.
1.01	4.25	53	.01	.00	.01	5.	1.01	16.25	197	.30	.30	.00	1230.
1.01	4.30	54	.01	.00	.01	6.	1.01	16.30	198	.30	.30	.00	1193.
1.01	4.35	55	.01	.00	.01	6.	1.01	16.35	199	.30	.30	.00	1179.
1.01	4.40	56	.01	.00	.01	7.	1.01	16.40	200	.30	.30	.00	1172.
1.01	4.45	57	.01	.00	.01	7.	1.01	16.45	201	.30	.30	.00	1170.
1.01	4.50	58	.01	.00	.01	8.	1.01	16.50	202	.30	.30	.00	1169.
1.01	4.55	59	.01	.00	.01	8.	1.01	16.55	203	.30	.30	.00	1169.
1.01	5.00	60	.01	.00	.01	9.	1.01	17.00	204	.30	.30	.00	1169.
1.01	5.05	61	.01	.00	.01	9.	1.01	17.05	205	.24	.24	.00	1143.
1.01	5.10	62	.01	.00	.01	9.	1.01	17.10	206	.24	.24	.00	1068.
1.01	5.15	63	.01	.00	.01	10.	1.01	17.15	207	.24	.24	.00	998.
1.01	5.20	64	.01	.00	.01	10.	1.01	17.20	208	.24	.24	.00	959.
1.01	5.25	65	.01	.00	.01	11.	1.01	17.25	209	.24	.24	.00	939.
1.01	5.30	66	.01	.00	.01	11.	1.01	17.30	210	.24	.24	.00	929.
1.01	5.35	67	.01	.00	.01	11.	1.01	17.35	211	.24	.24	.00	924.
1.01	5.40	68	.01	.00	.01	12.	1.01	17.40	212	.24	.24	.00	922.
1.01	5.45	69	.01	.00	.01	12.	1.01	17.45	213	.24	.24	.00	921.
1.01	5.50	70	.01	.00	.01	13.	1.01	17.50	214	.24	.24	.00	920.
1.01	5.55	71	.01	.00	.01	13.	1.01	17.55	215	.24	.24	.00	920.
1.01	6.00	72	.01	.00	.01	13.	1.01	18.00	216	.24	.24	.00	920.
1.01	6.05	73	.06	.02	.05	19.	1.01	18.05	217	.02	.02	.00	832.
1.01	6.10	74	.06	.02	.04	36.	1.01	18.10	218	.02	.02	.00	605.
1.01	6.15	75	.06	.02	.04	54.	1.01	18.15	219	.02	.02	.00	564.
1.01	6.20	76	.06	.02	.04	67.	1.01	18.20	220	.02	.02	.00	526.
1.01	6.25	77	.06	.02	.04	76.	1.01	18.25	221	.02	.02	.00	491.
1.01	6.30	78	.06	.03	.04	84.	1.01	18.30	222	.02	.02	.00	458.
1.01	6.35	79	.06	.03	.04	91.	1.01	18.35	223	.02	.02	.00	428.
1.01	6.40	80	.06	.03	.04	96.	1.01	18.40	224	.02	.02	.00	399.
1.01	6.45	81	.06	.03	.03	102.	1.01	18.45	225	.02	.02	.00	372.
1.01	6.50	82	.06	.03	.03	107.	1.01	18.50	226	.02	.02	.00	347.
1.01	6.55	83	.06	.03	.03	112.	1.01	18.55	227	.02	.02	.00	324.
1.01	7.00	84	.06	.03	.03	116.	1.01	19.00	228	.02	.02	.00	302.
1.01	7.05	85	.06	.03	.03	120.	1.01	19.05	229	.02	.02	.00	282.
1.01	7.10	86	.06	.03	.03	124.	1.01	19.10	230	.02	.02	.00	263.
1.01	7.15	87	.06	.04	.03	128.	1.01	19.15	231	.02	.02	.00	246.
1.01	7.20	88	.06	.04	.03	132.	1.01	19.20	232	.02	.02	.00	229.
1.01	7.25	89	.06	.04	.03	135.	1.01	19.25	233	.02	.02	.00	214.
1.01	7.30	90	.06	.04	.03	139.	1.01	19.30	234	.02	.02	.00	199.
1.01	7.35	91	.06	.04	.03	142.	1.01	19.35	235	.02	.02	.00	186.
1.01	7.40	92	.06	.04	.02	145.	1.01	19.40	236	.02	.02	.00	174.
1.01	7.45	93	.06	.04	.02	148.	1.01	19.45	237	.02	.02	.00	162.

PMF END-OF-PERIOD FLOW

1.01	7.50	94	.06	.04	.02	151.	1.01	19.50	238	.02	.02	.00	151.
1.01	7.55	95	.06	.04	.02	153.	1.01	19.55	239	.02	.02	.00	141.
1.01	8.00	96	.06	.04	.02	156.	1.01	20.00	240	.02	.02	.00	132.
1.01	8.05	97	.06	.04	.02	158.	1.01	20.05	241	.02	.02	.00	123.
1.01	8.10	98	.06	.04	.02	161.	1.01	20.10	242	.02	.02	.00	115.
1.01	8.15	99	.06	.04	.02	163.	1.01	20.15	243	.02	.02	.00	107.
1.01	8.20	100	.06	.04	.02	165.	1.01	20.20	244	.02	.02	.00	100.
1.01	8.25	101	.06	.04	.02	167.	1.01	20.25	245	.02	.02	.00	93.
1.01	8.30	102	.06	.04	.02	169.	1.01	20.30	246	.02	.02	.00	87.
1.01	8.35	103	.06	.05	.02	171.	1.01	20.35	247	.02	.02	.00	82.
1.01	8.40	104	.06	.05	.02	173.	1.01	20.40	248	.02	.02	.00	82.
1.01	8.45	105	.06	.05	.02	175.	1.01	20.45	249	.02	.02	.00	82.
1.01	8.50	106	.06	.05	.02	177.	1.01	20.50	250	.02	.02	.00	82.
1.01	8.55	107	.06	.05	.02	179.	1.01	20.55	251	.02	.02	.00	82.
1.01	9.00	108	.06	.05	.02	180.	1.01	21.00	252	.02	.02	.00	82.
1.01	9.05	109	.06	.05	.02	182.	1.01	21.05	253	.02	.02	.00	82.
1.01	9.10	110	.06	.05	.02	183.	1.01	21.10	254	.02	.02	.00	82.
1.01	9.15	111	.06	.05	.02	185.	1.01	21.15	255	.02	.02	.00	82.
1.01	9.20	112	.06	.05	.02	186.	1.01	21.20	256	.02	.02	.00	82.
1.01	9.25	113	.06	.05	.01	187.	1.01	21.25	257	.02	.02	.00	82.
1.01	9.30	114	.06	.05	.01	189.	1.01	21.30	258	.02	.02	.00	82.
1.01	9.35	115	.06	.05	.01	190.	1.01	21.35	259	.02	.02	.00	82.
1.01	9.40	116	.06	.05	.01	191.	1.01	21.40	260	.02	.02	.00	82.
1.01	9.45	117	.06	.05	.01	193.	1.01	21.45	261	.02	.02	.00	82.
1.01	9.50	118	.06	.05	.01	194.	1.01	21.50	262	.02	.02	.00	82.
1.01	9.55	119	.06	.05	.01	195.	1.01	21.55	263	.02	.02	.00	82.
1.01	10.00	120	.06	.05	.01	196.	1.01	22.00	264	.02	.02	.00	82.
1.01	10.05	121	.06	.05	.01	197.	1.01	22.05	265	.02	.02	.00	82.
1.01	10.10	122	.06	.05	.01	198.	1.01	22.10	266	.02	.02	.00	82.
1.01	10.15	123	.06	.05	.01	199.	1.01	22.15	267	.02	.02	.00	82.
1.01	10.20	124	.06	.05	.01	200.	1.01	22.20	268	.02	.02	.00	82.
1.01	10.25	125	.06	.05	.01	201.	1.01	22.25	269	.02	.02	.00	82.
1.01	10.30	126	.06	.05	.01	202.	1.01	22.30	270	.02	.02	.00	82.
1.01	10.35	127	.06	.05	.01	203.	1.01	22.35	271	.02	.02	.00	82.
1.01	10.40	128	.06	.05	.01	203.	1.01	22.40	272	.02	.02	.00	82.
1.01	10.45	129	.06	.05	.01	204.	1.01	22.45	273	.02	.02	.00	82.
1.01	10.50	130	.06	.05	.01	205.	1.01	22.50	274	.02	.02	.00	82.
1.01	10.55	131	.06	.05	.01	206.	1.01	22.55	275	.02	.02	.00	82.

PMF END-OF-PERIOD FLOW

1.01	11.00	132	.06	.05	.01	207.	1.01	23.00	276	.02	.02	.00	82.
1.01	11.05	133	.06	.05	.01	207.	1.01	23.05	277	.02	.02	.00	82.
1.01	11.10	134	.06	.05	.01	208.	1.01	23.10	278	.02	.02	.00	82.
1.01	11.15	135	.06	.05	.01	209.	1.01	23.15	279	.02	.02	.00	82.
1.01	11.20	136	.06	.05	.01	210.	1.01	23.20	280	.02	.02	.00	82.
1.01	11.25	137	.06	.05	.01	210.	1.01	23.25	281	.02	.02	.00	82.
1.01	11.30	138	.06	.05	.01	211.	1.01	23.30	282	.02	.02	.00	82.
1.01	11.35	139	.06	.05	.01	212.	1.01	23.35	283	.02	.02	.00	82.
1.01	11.40	140	.06	.05	.01	212.	1.01	23.40	284	.02	.02	.00	82.
1.01	11.45	141	.06	.06	.01	213.	1.01	23.45	285	.02	.02	.00	82.
1.01	11.50	142	.06	.06	.01	213.	1.01	23.50	286	.02	.02	.00	82.
1.01	11.55	143	.06	.06	.01	214.	1.01	23.55	287	.02	.02	.00	82.
1.01	12.00	144	.06	.06	.01	214.	1.02	0.00	288	.02	.02	.00	82.
									SUM	33.15	29.99	3.16	120759.
										(842.)	(762.)	(80.)	(3419.51)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6089.	1351.	419.	419.	120728.
CMS	172.	38.	12.	12.	3419.
INCHES		25.04	31.07	31.07	31.07
MM		635.95	789.22	789.22	789.22
AC-FT		670.	831.	831.	831.
THOUS CU M		826.	1026.	1026.	1026.

SURFACE AREA=	0.	21.	25.	33.	44.	55.
CAPACITY=	0.	183.	274.	562.	943.	1435.
ELEVATION=	520.	546.	550.	560.	570.	580.

SUMMARY OF DAM SAFETY ANALYSIS
RATIOS OF PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	546.00	546.00	550.10
STORAGE	183.	183.	277.
OUTFLOW	0.	0.	372.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	550.06	0.00	276.	360.	0.00	16.17	0.00
.50	552.20	2.10	330.	1903.	4.33	15.92	0.00
1.00	553.28	3.18	359.	5231.	6.92	15.75	0.00

SUMMARY OF DAM SAFETY ANALYSIS
100-YEAR FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	546.00	546.00	550.10
STORAGE	183.	183.	277.
OUTFLOW	0.	0.	372.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	548.11	0.00	229.	32.	0.00	15.75	0.00

DATE
FILMED